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INTERIM REPORT ON
EARTHWORK COMPACTION CONTROL
BY PERCENT AIR VOIDS

JAMES J. HOWARD
Engineer-In-Training

August 1972

Idaho Department of Highways
Boise, Idaho

AFFIDAVIT
TO ACCOMPANY
ENGINEERING REPORT SUBMITTED WITH APPLICATION FOR PROFESSIONAL ENGINEER
TO THE IDAHO STATE BOARD OF ENGINEERING EXAMINERS

ENTITLED

INTERIM REPORT ON

EARTHWORK COMPACTION CONTROL

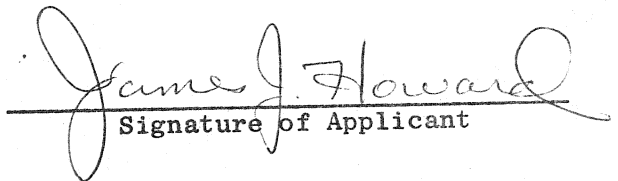
BY PERCENT AIR VOIDS

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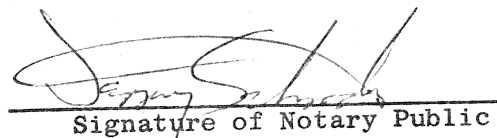
I, James J. Howard, being first duly sworn, depose and say:

That the attached engineering report is of my own composition except as follows:

Guidance and supervision by Walt Jones, P. E.


Signature of Applicant

Subscribed and sworn to before me this 28 day of August, 1972.


Signature of Notary Public

My Commission Expires 7-28-75

Residence: Boise Idaho
City State

(SEAL)

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ABSTRACT

The Department of Highways has used the Proctor method of earthwork compaction control almost continually since its introduction by R. R. Proctor.

The percent air-voids concept of compaction control could expedite testing procedures and solve problems long associated with present test methods.

The air voids method was tested along side four earthwork projects. Test results indicated that this new method could be implemented if moisture controls were adopted.

ACKNOWLEDGMENTS

Recognition and appreciation is given to Walt Jones, Soils Engineer, for guidance and preliminary research on the project.

Special thanks are given to Jim Gore, E.T. VII; Dee Burie, E.I.T.; and the Lab technicians of the Central Laboratory for the expeditious handling of soil samples.

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TABLE OF CONTENTS

	<u>PAGE</u>
INTRODUCTION	1
Purpose	1
Sources of Information	1
Authorization	1
PROCTOR METHOD OF EARTHWORK COMPACTION CONTROL	2
History	2
Associated Problems	2
THE AIR VOIDS CONCEPT	4
TESTING PROCEDURES	5
Field Tests	5
Laboratory Tests	5
EVALUATION OF TEST RESULTS	6
The Air Voids Curves	6
Moisture Control	8
Nuclear Testing Methods	8
INTERIM RECOMMENDATIONS	10
BIBLIOGRAPHY	11
APPENDIX	12
Table I	13
Table II	14
Table III	16
Exhibit I	18
Exhibit II	19
Exhibit III	20
Exhibit IV	21
Graph I	22
Graph II	23
Graph III	24
Graph IV	25
Graph V	26
Graph VI	27

INTRODUCTION

Purpose

The primary purpose of this report is to present a study of a relatively new method of earthwork compaction control and to draw conclusions and make recommendations based on this study.

Sources of Information

The information contained in this report was gathered and compiled from (1) a field program of testing along side the Idaho Highway Department's present control methods, (2) Central Laboratory testing and evaluation of materials retrieved from field test sites, (3) personal experience of the author and Walter Jones, Soils Engineer, Department of Highways, (4) listed references within the text of this report.

Authorization

The study was authorized by the Research Committee, Idaho Department of Highways, in a meeting held May 1, 1972.

PROCTOR METHOD OF EARTHWORK COMPACTION CONTROL

History

The Department of Highways has relied entirely on the Proctor Method of earthwork compaction control since the late thirty's. The Proctor Method, developed by R. R. Proctor in 1934 came when mechanized earth moving was in its infancy.

Through the years it has gained wide acceptance and is used extensively by numerous State and Federal agencies. The test filled a need to help control settlements and increase strength of soils within a range that was attainable by the construction equipment. Some engineers have construed "Maximum Density" and "Optimum Moisture" as absolutes, not realizing that changes in soil types, compaction equipment and the energy expended in compacting the soil caused densities that may or may not be equivalent to the "Maximum" Proctor Density.

Associated Problems

As valuable as the Proctor Method of compaction control is, it still has inherent weaknesses. Listed below are some of the problems that may be encountered with this method of control.

- (1) Field technicians that are engaged in compaction work are usually seasonal help and lack the needed experience in testing procedures.
- (2) On large projects where the soil type is variable a large number of field curves may exist. This coupled with the inspectors lack of experience compounds the problem of proper curve selection.
- (3) Standard Laboratory curves often times are useless due to processing or mixing of different soil types. Mixing of soil necessitates additional time spent in pounding field curves.

(4) This method is slow and consumes a large amount of time for its net return. With the rate of earthwork production on the increase the number of tests per unity quantity gets less unless additional field technicians are used.

(5) Since the test is moderately complex, there are more areas subject to error by the inexperienced technicians.

(6) Reproducibility of results of the Proctor Method is a problem.

Sometimes soils that contain high proportions of large aggregates, soils that degrade under the compactive effort and expansive clays all show a high degree of variability. Reproducibility of ± 2 lbs. from the median is not unusual even on repetition of the test by the same operator. Deviation from the median optimum moisture content may be even larger. Table I entitled "Proctor Curves" serves as an example of the variability of Proctor Curves made up on identical soils. For a given sample number, the densities and moistures under the columns entitled "Field Curves" and "Research Curves" should be identical if all testing and operator error were removed.

THE AIR VOIDS CONCEPT

Soil is a porous material containing solid particles interspersed with voids. These voids may be filled with air, with water or with a combination of both.

The percent air voids of a soil depends upon the degree of compaction or density. Therefore, the percent air voids can be used to judge relative stability and load carrying capacity of soil at optimum moisture conditions with these factors increasing as the air voids decrease.

Graph I is a typical air voids plot. Shown on the abscissa is percent moisture, dry density on the ordinate. Air void curves for zero, ten, and twenty percent are plotted for various specific gravities. These curves are a function of, but not sensitive to changes in specific gravity. Only three to five pounds difference can be detected for specific gravities ranging from 2.55 to 2.70 under any family of curves (See Graph I).

In order to use the air voids concept for compaction control one or more sets of air voids curves could be prepared for a project. The number required would be dependent upon the range of specific gravities of soils encountered on that job. In most cases a single curve might prove adequate.

In-place densitys and moisture tests would be taken by nuclear or Washington densometer methods. The moisture and density would be plotted on the graph with the air voids curves. This point would fall either above or below a selected air void control specification. If 10% air void (specific gravity 2.70) were the specification for compaction control then test One would be passing, Test Two failing (Graph I). Selection of a specification curve will be discussed later in this report.

TESTING PROCEDURES

Tests were conducted on four widely separated projects. Analysis of soil samples indicated a fair cross section of soil type had been made, ranging from poorly graded sands to inorganic silts and clays.

Field Tests

The compaction control inspector prepared the test site according to Idaho T-14. After preparation the Nuclear Densometer was placed directly over the intended test site and in place moisture and density readings were taken. With the completion of nuclear tests, the inspector completed in place testing with the Washington Densometer. A sample of soil was obtained from the test site for further Central Lab testing.

Laboratory Tests

The Central Laboratory ran gradations, combined specific gravities, moisture-density curves (AASHO T-99) and Atterberg limits, for the samples submitted. Gradations and Atterberg limits were used to classify samples. Combined specific gravities were used in constructing the correct air-void curves. Moisture density curves served as a check on reliability and reproducibility of field curves. Table II is a summary of laboratory tests performed on the samples submitted.

Exhibit I is a sample nuclear density report form, Exhibit II, Inspectors Daily Compaction Report, Exhibit III, Standard Moisture Density Field Curve, Exhibit IV, Central Lab Soils Master Report Sheet.

EVALUATION OF TEST RESULTS

The Air Voids Curves

Graphs II, III, IV and V are the air voids curves for the four projects studied.

An examination of the Central Laboratory Summary Sheet (Table II) will show that each project has an average specific gravity of 2.65, the exception, Sandpoint, with an average of 2.75. Hence all air voids curves, with the exception of Sandpoint, ^{WERE} prepared for specific gravities of 2.65.

Shown on each plot are the 0, 5, 10 and 12.5 percent air void curves. 12.5 percent was selected as the pass-fail curve. Selection of 12.5% as the specification air void line is based in part to Graph VI. Shown on this graph is a family of curves prepared by the standard Proctor method on different soil types. The 5% air voids curves intersect each curve at optimum conditions. The locus of all points plotted at 95% of optimum conditions fall on or very near the 12.5% air voids curve; hence its use as the control curve.

Rain prior to and during the week at Sandpoint (Graph II) resulted in a small number of tests. Those tests that were obtained were on the wet side of optimum. Point four on this plot is beyond the zero air void curve which in theory is impossible. Nuclear and Washington in-place density readings normally in close agreement were widely separated in this case, testing error is suspected for this disparity.

Soils on the Idaho-Oregon Line project showed high optimum moistures and low densities. The special provisions allowed 90% of optimum conditions as passing. Although an air void curve for 90% is not shown on this Graph (Graph III) the tests shown as failing under the 95% compaction requirement would have been passing under an air void curve representing 90% compaction.

Graph IV, Interstate Grading Near Hammett, shows excellent grouping and good correlation to Proctor densities and percent compaction. A review of the Central Lab Summary Sheet will show an average optimum moisture of about nine to ten percent. In-place moistures were very near optimum. The contractor was prewetting the cut sections and getting compaction without any apparent difficulties. The real key to getting good correlation between Proctor and air void methods seems to be in controlling moisture to near optimum conditions.

The material encountered on the Pocatello Interstate Grading Project was a sandy loam with an average moisture content of 13%. Most failing points on the air voids graph (Graph V) were considerably dry of optimum moisture. The under optimum moisture condition made movement and compaction difficult. The top layer was very fluffy and could not be tested. The top foot had to be removed in order to find material that had enough moisture and confinement for testing. If the material had been near optimum all tests, with the exception of Test 1, would have been passing.

Moisture Control

It is generally agreed that three basic factors influence compaction, (1) physical properties such as grain size distribution (2) the amount as well as the type of compactive effort (3) and the moisture content. Physical properties can be controlled to some extent by proper location of the highway and source investigations. The Department of Highways places no controls on moisture content or compaction methods.

What long-term affect does compacting material dry of optimum have? Is this a favorable or unfavorable condition? Some proponents of moisture control maintain that without control, internal stress are created in earth masses during construction which in time give way to earth movement.

What affect moisture does have is not perfectly clear, however, it is self evident that without some method of controlling moisture the air voids concept of compaction control will not give results that parallel the Proctor method.

Nuclear Testing Methods

If an air voids concept of compaction control were implemented the nuclear densometer would enable the compaction inspector to know within minutes the results of any test. In-place densities and moistures are only seconds away instead of hours. With capabilities such as this the inspector can get immediate results which benefits him and the contractor.

Since the Department of Highways has not done extensive field testing with the nuclear densometer in soils, tests were taken along side the compaction crew to get a comparative view. Table III is the result of densities and moistures taken by both methods. Examination of the Table reveals that the nuclear densometer compares favorably to the Washington densometer.

Comparative moistures in most cases are acceptable, however, in some cases anomalies did occur. To fully utilize the nuclear densometer continued studies may be necessary to isolate the conditions or soil types creating erroneous moisture readings.

INTERIM RECOMMENDATIONS

Based on available data certain interim recommendations can be made. It is proposed that the air voids method of compaction control be set into the supplemental specification of a earthwork project on a trial basis. A conditional part of this trial should be a moisture control which would regulate moisture to near optimum conditions.

If moisture control is rejected the air voids system appears to be of questionable value.

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APPENDIX

TABLE I
PROCTOR CURVES

Project	Sample Number	Field Curves		Research Curves	
		Max. Density lbs/ft ₃	Optimum Moist. %	Max. Density lbs/ft ₃	Optimum Moist. %
I-80N-2(42)96	1 CX	120.6	10.6	118.3	10.6
	2 CX	122.1	8.6	124.3	8.6
	4 CX	121.0	11.5	117.8	11.7
	5 CX	120.6	10.6	116.0	10.4
	6 CX	125.0	7.4	121.8	9.9
	7 CX	122.1	10.8	124.1	8.3
	8 CX	122.1	8.6	121.2	9.2
	9 CX	116.8	13.2	115.3	12.3
	10 CX	122.1	10.8	120.7	10.4
	11 CX	120.6	10.6	119.8	8.6
	12 CX	120.6	10.6	122.7	9.5
F-FG-5116(23)	1 CX	105.5	20.4	110.3	17.3
	2 CX	105.5	20.4	111.6	15.9
	3 CX	105.5	20.4	109.8	15.6
	4 CX	104.2	23.0	113.9	15.4
FL-11-1(2)	1 CX	71.4	42.6	80.0	34.6
	2 CX	71.4	42.6	76.4	36.3
	3 CX	66.0	50.7	69.0	44.4
	4 CX	68.1	49.0	70.0	36.7
	5 CX	73.5	39.0	71.6	39.7
	6 CX	68.1	49.0	70.0	38.7
	7 CX	66.0	50.7	67.0	49.0
I-15W-4(12)81"A"	1 CX	108.6	15.8	112.4	15.0
	2 CX	101.0	14.7	106.6	14.8
	3 CX	120.4	12.5	125.1	10.0
	4 CX	125.4	10.6	122.9	11.3
	5 CX	116.5	12.2	114.4	14.1
	6 CX	116.4	11.5	123.9	10.9
	7 CX	111.2	13.8	113.9	14.0
	8 CX	108.9	10.5	112.6	14.3
	9 CX	108.6	15.8	116.6	13.5
	10 CX	114.1	13.1	118.9	12.3
	11 CX	114.1	13.1	115.4	13.1
	12 CX	111.8	14.2	115.8	12.2

TABLE II
SUMMARY OF CENTRAL LAB TEST RESULTS ON FIELD SAMPLES
I-80N-2(42)96
(Hammett)

Test Number	Specific Gravity	% Passing		Maximum Dry Density lbs/ft ³	Optimum Moisture %	AASHO Classification	Unified Classification
		No. 20	No. 200				
1 CX	2.48	71	34	118.3	10.6	A-2-4(0)	SM
2 CX	2.63	55	18	124.3	8.6	A-1-b(0)	SM
3 CX	2.45	73	21	116.6	10.6	A-2-4(0)	SM
4 CX	2.65	77	30	117.8	11.7	A-2-4(0)	SM
5 CX	2.66	77	24	116.0	10.4	A-2-4(0)	SM
6 CX	2.63	74	35	121.8	9.9	A-2-4(0)	SM
7 CX	2.63	65	18	124.1	8.3	A-2-4(0)	SM
8 CX	2.62	70	21	121.2	9.2	A-2-4(0)	SM
9 CX	2.64	84	28	115.3	12.3	A-2-4(0)	SM
10 CX	2.64	71	19	120.7	10.4	A-2-4(0)	SM
11 CX	2.62	67	21	119.8	8.6	A-2-4(0)	SM
12 CX	2.64	73	23	122.7	9.5	A-2-4(0)	SM

FL-11-1(2)
(Idaho - Oregon Line)

Test Number	Specific Gravity	% Passing		Maximum Dry Density lbs/ft ³	Optimum Moisture %	AASHO Classification	Unified Classification
		No. 20	No. 200				
1 CX	2.65	83	60	80.0	34.6	A-7-5(15)	CH
2 CX	2.59	90	57	76.4	36.3	A-7-5(14)	CH
3 CX	2.59	98	59	69.0	44.4	A-7-5(15)	MH
4 CX	2.65	88	68	70.0	36.7	A-7-5(18)	MH
5 CX	2.71	87	66	71.6	39.7	A-7-5(17)	MH
6 CX	2.69	96	61	70.0	38.7	A-4(5)	ML
7 CX	2.67	96	64	67.0	49.0	A-7-5(17)	MH

TABLE II (Continuation)
F-FG-5116(23)
(Sandpoint)

Test Number	Specific Gravity	% Passing		Maximum Dry Density lbs/ft ³	Optimum Moisture %	AASHTO Classification	Unified Classification
		No. 20	No. 200				
1 CX	2.77	100	94	110.3	17.0	A-4(8)	ML - CL
2 CX	2.70	99	92	111.6	15.9	A-4(8)	ML - CL
3 CX	2.74	99	91	109.8	15.6	A-4(8)	ML
4 CX	2.74	98	79	113.9	15.4	A-4(8)	ML - CL

I-15W-4(12)81"A"
(Pocatello)

Test Number	Specific Gravity	% Passing		Maximum Dry Density lbs/ft ³	Optimum Moisture %	AASHTO Classification	Unified Classification
		No. 20	No. 200				
1 CX	2.65	100	38	112.4	15.0	A-4(1)	SM
2 CX	2.65	100	18	106.6	14.8	A-2-4(0)	SM
3 CX	2.68	86	31	125.1	10.0	A-2-4(0)	SM
4 CX	2.67	94	35	122.9	11.3	A-2-4(0)	SM
5 CX	2.69	85	11	114.4	14.1	A-1-b(0)	SP - SM
6 CX	2.69	95	50	123.9	10.9	A-4(3)	SM
7 CX	2.70	90	62	113.9	14.0	A-4(5)	ML
8 CX	2.68	81	10	112.6	14.3	A-1-b(0)	SP - SM
9 CX	2.68	98	67	116.6	13.5	A-4(6)	ML
10 CX	2.66	99	37	118.9	12.3	A-4(0)	SM
11 CX	2.67	99	58	115.4	13.1	A-4(5)	ML
12 CX	2.67	100	44	115.8	12.2	A-4(2)	SM

TABLE III
COMPARATIVE FIELD TESTS
NUCLEAR DENSOMETER VS. WASHINGTON DENSOMETER

I-80N-2(42)96
(Hammett)
Unified Classification SM

Test Number	Nuclear Data		Washington Dens-o-meter and Oven Dried Moisture	
	Wet Density	% Moisture	Wet Density	% Moisture
1 CX	128.0	11.1	128.1	9.6
2 CX	132.5	8.4	135.3	7.4
3 CX	125.0	9.2	--	--
4 CX	123.5	10.8	128.4	10.0
5 CX	128.5	11.0	130.2	9.2
6 CX	134.5	12.3	135.2	7.1
7 CX	126.0	9.6	135.2	9.1
8 CX	130.5	8.8	131.4	7.7
9 CX	131.0	13.7	130.3	12.4
10 CX	129.5	10.7	133.0	8.6
11 CX	134.0	10.4	134.3	10.0
12 CX	130.5	9.2	131.1	10.3

F-FG-5116(23)
(Sandpoint)
Unified Classification ML-CL

Test Number	Nuclear Data		Washington Dens-o-meter and Oven Dried Moisture	
	Wet Density	% Moisture	Wet Density	% Moisture
1 CX	127.5	18.6	127.4	21.4
2 CX	130.0	18.2	132.3	19.1
3 CX	122.0	19.9	126.4	20.3
4 CX	123.5	19.6	136.5	22.5

TABLE III (Continuation)

FL-11-1(2)
(Idaho - Oregon Line)
Unified Classification MH-CH

Test Number	Nuclear Data		Washington Dens-o-meter and Oven Dried Moisture	
	Wet Density	% Moisture	Wet Density	% Moisture
1 CX	97.5	26.4	96.3	34.4
2 CX	104.0	28.9	98.9	34.4
3 CX	103.0	34.7	99.3	46.4
4 CX	103.0	31.8	100.8	37.2
5 CX	103.0	29.2	100.8	31.6
6 CX	100.5	35.9	92.3	47.7
7 CX	100.5	37.7	94.6	45.4

I-15W-4(12)81"A"
(Pocatello)
Unified Classification SM-SP

Test Number	Nuclear Data		Washington Dens-o-meter and Oven Dried Moisture	
	Wet Density	% Moisture	Wet Density	% Moisture
1 CX	117.0	9.1	114.2	11.1
2 CX	114.0	5.8	112.0	4.6
3 CX	129.5	9.7	133.6	8.2
4 CX	125.0	11.4	135.0	7.5
5 CX	120.0	6.4	119.1	5.0
6 CX	122.0	11.9	121.7	8.7
7 CX	124.5	15.8	126.9	14.9
8 CX	121.0	6.4	120.6	4.8
9 CX	121.5	17.4	119.4	15.1
10 CX	127.0	10.9	125.5	9.9
11 CX	123.0	13.1	130.6	10.6
12 CX	118.0	13.5	121.0	11.1

PROJECT NO. FL-11-1(2) DIST. 3ITEM NO. 205A SOURCE -TEST BY Jim Howard DATE 7-21-72GAUGE MAKE TROYLER MODEL 2401 SER. NO. 1635REMARKS: Large rock found in bottom of hole on SCx
Test 7Cx batteries are low-

TEST NO.	4Cx		5Cx		6Cx		7Cx	
FIELD TEST NO.	45		46		47		48	
LOCATION	162+50		161+60		159+90		163+00	
OFFSET	12' LT		65' LT		45' RT		12' RT	
DEPTH FROM SUB. GR.	15'		15'		15'		12'	
MODE & DEPTH	15' + 2" + 100T		15' + 2" + 100T		15' + 2" + 100T		15' + 2" + 100T	
STANDARD COUNT	DEN.	MOIST.	DEN.	MOIST.	DEN.	MOIST.	DEN.	MOIST.
	447	441						
	446							
DENSITY COUNT	1 596		1 596		1 623		1 621	
	2 597		2 592		2 622		2 620	
	3		3 597		3		3	
DENSITY COUNT RATIO	$\frac{596}{447} = 1.331$		$\frac{596}{447} = 1.331$		$\frac{622}{447} = 1.39$		$\frac{621}{447} = 1.39$	
WET DENSITY	103.0 PCF		103.0 PCF		100.5 PCF		100.5 PCF	
MOISTURE COUNT	1 459		1 434		1 489		1 498	
	2 456		2 435		2 481		2 470	
	3 483		3 412		3 477		3	
MOISTURE COUNT RATIO	$\frac{459}{441} = 1.04$		$\frac{435}{441} = .986$		$\frac{481}{441} = 1.09$		$\frac{498}{441} = 1.13$	
MOISTURE	24.75 PCF		23.25 PCF		26.25 PCF		27.25 PCF	
DRY DENSITY	77.25 PCF		79.75 PCF		73.25 PCF		72.25 PCF	
% MOISTURE	31.8		29.2		35.7		37.7	

Exhibit II

DAILY COMPACTION REPORT



PROJECT FL 11-1(2) FIELD TEST No. 45 4CX Compaction Class A Report No. _____ Date 2-21-72

1. NOTE On projects involving small quantities of earthwork this form may be submitted weekly.

Test No.	<u>45</u> <u>4CX</u>	<u>46</u> <u>5CX</u>	<u>47</u> <u>6CX</u>	<u>48</u> <u>7CX</u>
Station	<u>162+50</u>	<u>161+60</u>	<u>159+90</u>	<u>163+00</u>
Distance from Centerline	<u>12' Lt</u>	<u>65' Lt</u>	<u>45' Rt</u>	<u>12' Rt</u>
Depth from subgrade	<u>15'</u>	<u>15'</u>	<u>14'</u>	<u>12'</u>

Contract Item No.		205A	205A	205A	205A	
VOLUME OF HOLE	Initial Wt. Sand	Final Reading "A"	0.141	0.138	0.149	0.145
	Final Wt. Sand	Ring Constant "C"	0.100	0.100	0.100	0.100
	Wt. Sand in Hole	"A" + "C"	0.241	0.238	0.249	0.245
	Unit Wt. Sand	Initial Reading "B"	0.136	0.138	0.137	0.137
	Volume of Hole	Vol. Hole (A+C-B)	0.105	0.100	0.112	0.103

Standard Density - Method		A		A		A		A	
IN PLACE	PROCTOR*	IP	P	IP	P	IP	P	IP	P
Wet Wt. Soil + Tare	Wet Wt. Soil + Mold	12.42	10.48	11.78	10.53	12.18	10.75	11.92	10.44
Tare	Mold	1.84	7.50	1.70	7.50	1.84	7.50	1.70	7.50
Wet Wt. Soil	Wet Wt. Soil	10.58	2.98	10.08	3.03	10.34	3.25	10.22	2.94
Wet Density	Wet Density	100.8	89.4	100.8	90.9	92.3	97.5	94.6	88.2
Dry Density	Dry Density*	73.5	65.2	76.6	69.1	62.5	66.0	65.1	60.7

Specific Gravity + ¾"										
MOIST. CONTENT	IN PLACE	PROCTOR*	IP	P	IP	P	IP	P	IP	P
	Wet Wt. Soil		177		275		319		237	
	Dry Wt. Soil		129		209		216		163	
	Wt. Moisture		48		66		103		74	
	% Moisture		37.2		31.6		47.7		45.4	

PERCENT COMPACTION	% Compaction Required	<u>95</u>	<u>95</u>	<u>95</u>	<u>95</u>
	Lab. No. of Standard Curve	<u>Field Cv. #9</u>	<u>Field Cv. #5</u>	<u>Field Cv. #9</u>	<u>Field Cv. #10</u>
	Standard Density	<u>68.1</u>	<u>73.5</u>	<u>68.1</u>	<u>66.0</u>
	Optimum Moisture	<u>49.0</u>	<u>39.0</u>	<u>49.0</u>	<u>50.7</u>
	*Density from Standard Curve at in-place moisture/Proctor Moisture	<u>63.8</u>	<u>69.9</u>	<u>68.0</u>	<u>61.1</u>
	In-place Density	<u>73.5</u>	<u>76.6</u>	<u>62.5</u>	<u>65.1</u>
	* In-place Moisture/Proctor Moisture	<u>37.2</u>	<u>31.6</u>	<u>47.7</u>	<u>45.4</u>
	Percent Minus No. 4/Percent Minus 3/4"	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>
	Density at Field Gradation	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>
	Percent Compaction	<u>106</u>	<u>104</u>	<u>92</u>	<u>99</u>

*Check points for proper curve selection.

INSPECTOR A.K. Miller

CHECKED BY _____

Distribution : Matls. Engr. Dist. Matls. Engr. Res. Engr. Inspector

DH-804 ML 1-63
Copies to:
Highway Engr.
District Engr.
Resident Engr.
B. P. R.
File

STATE OF IDAHO
DEPARTMENT OF HIGHWAYS
Materials Laboratory
District 03

Exhibit III

Lab. No. _____
Field Curve No. 9

Project FL 11-1 (2) Report of Tests on SOIL _____
Submitted by Miller County Wayne Source No. _____
Station 197 Ident. No. _____
Description of Soil Clay Layer No. _____ Depth 50'
Date Sampled 7/12/72 Received _____

Mechanical Analysis

% Passing

3" Sq. _____
2" Sq. _____
1" Sq. _____
3/4" Sq. _____
1/2" Sq. _____
No. 4 _____
No. 10 _____
No. 20 _____
No. 30 _____
No. 40 _____
No. 50 _____
No. 100 _____
No. 200 _____

Soil Constants

Liquid Limit _____
Plastic Limit _____
Plasticity Index _____
Field Moist. Equiv. _____
Linear Shrinkage _____

Specific Gravity (+3/4) _____
Specific Gravity (-No. 4) _____

Equation "A" No. _____

Texture Class'n. _____
Soil Class'n. _____

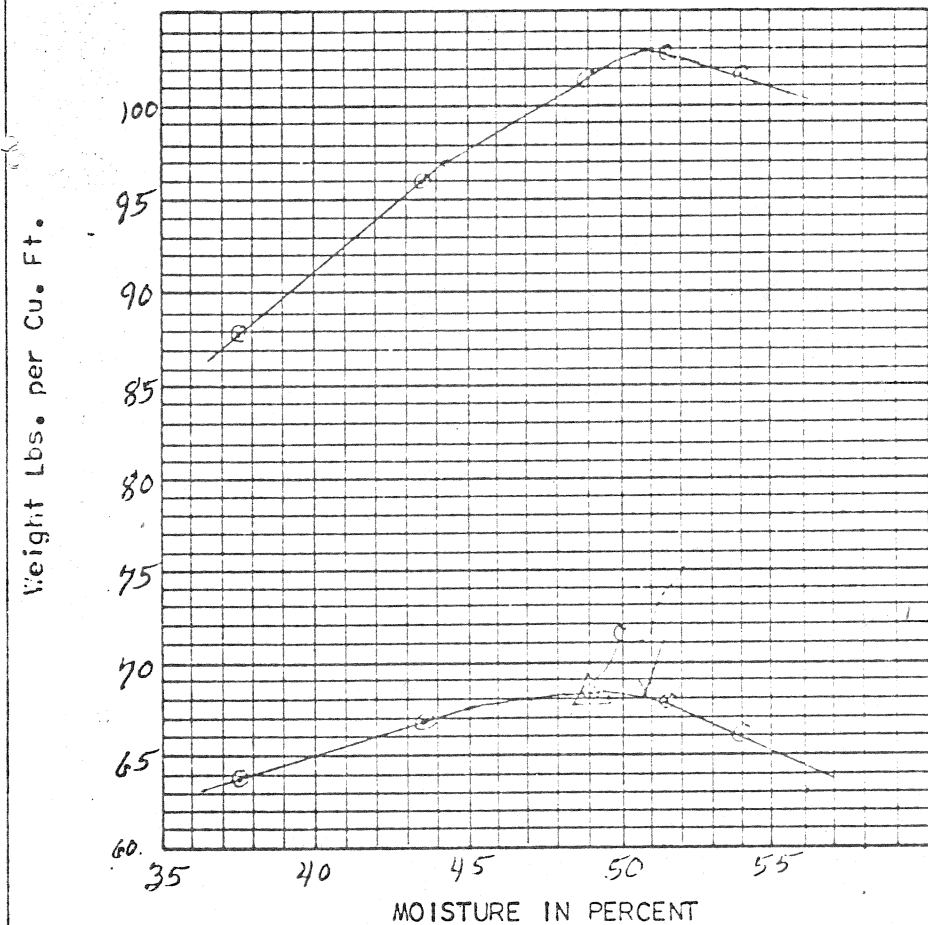
Sand Equivalent _____

Remarks _____

MOISTURE-DENSITY CURVE AASHTO DESIGNATION T 99 METHOD A

Max. Dry Wt. 68.1 #/Cu. Ft. Opt. Moist. 49.0 %

Corrected Max. Dry Wt. = _____ Lb./Cu. Ft.
(Correction at _____ % passing the 3/4")



INSPECTOR G. K. Miller

This report covers only material as represented by this sample and does not necessarily cover all soil from this layer.

Date Mailed 8-1-72

~~XXXXXXXXXX~~ C. E. HOPKINS, P.E.
Materials Engineer

DH-803 4-67

IDAHO DEPARTMENT OF HIGHWAYS

Central Laboratory

Boise, Idaho

Exhibit IVLab. No. 257497

Distribution:

Hwy. Engr.

Dist. Engr.

Res. Engr.

Report of Tests on SOIL RESEARCH FOR COMPACTION CONTROL BY

/AIR VOIDS

Project RESEARCH 66 (FL 11-1(2))County OWYHEESource No. Submitted by J. HOWARDIdent. No. JJH/99056-1316/4-CXStation 162+50 12' LT. CL.Layer No. Depth 15' FROM SUBGRADEDescription of Soil Date Sampled 7-21-72Received 7-31-72

Mechanical Anal. % Pass

3"	Sq.	
2"	Sq.	<u>100</u>
1"	Sq.	<u>98</u>
3/4"	Sq.	<u>96</u>
1/2"	Sq.	<u>95</u>
No. 4		<u>95</u>
No. 10		<u>92</u>
No. 20		<u>88</u>
No. 30		<u>86</u>
No. 40		<u>85</u>
No. 50		<u>83</u>
No. 100		<u>75</u>
No. 200		<u>68</u>

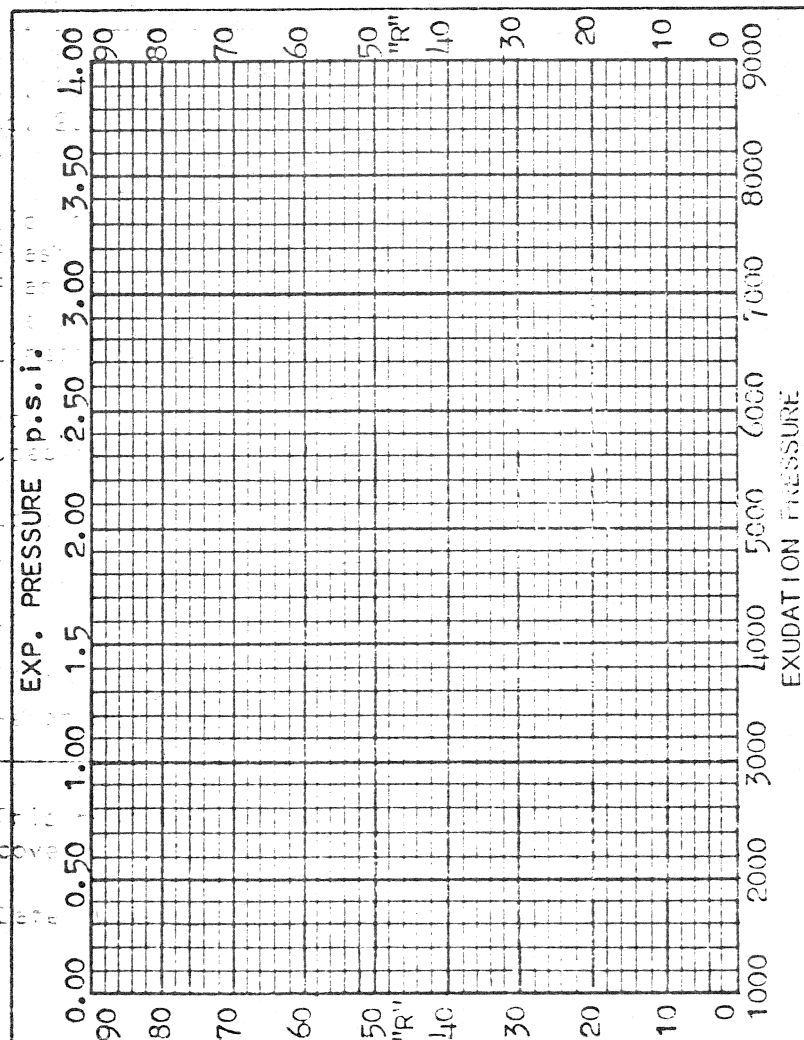
Soil Constants

Liquid Limit	<u>91</u>
Plastic Limit	<u>43</u>
Plasticity Index	<u>48</u>
Field Moist. Equiv.	<u> </u>
Linear Shrinkage	<u> </u>
Specific Gravity (+3/4")	<u> </u>
Specific Gravity (-No. 4)	<u>2.65</u>
Sand Equivalent	<u> </u>
"R" Value	<u> </u>
Exp. Pressure, psi	<u> </u>
Unified Class'n	<u>MH</u>
AASHTO Class'n	<u>A-7-5 (18)</u>
Traffic Index	<u> </u>

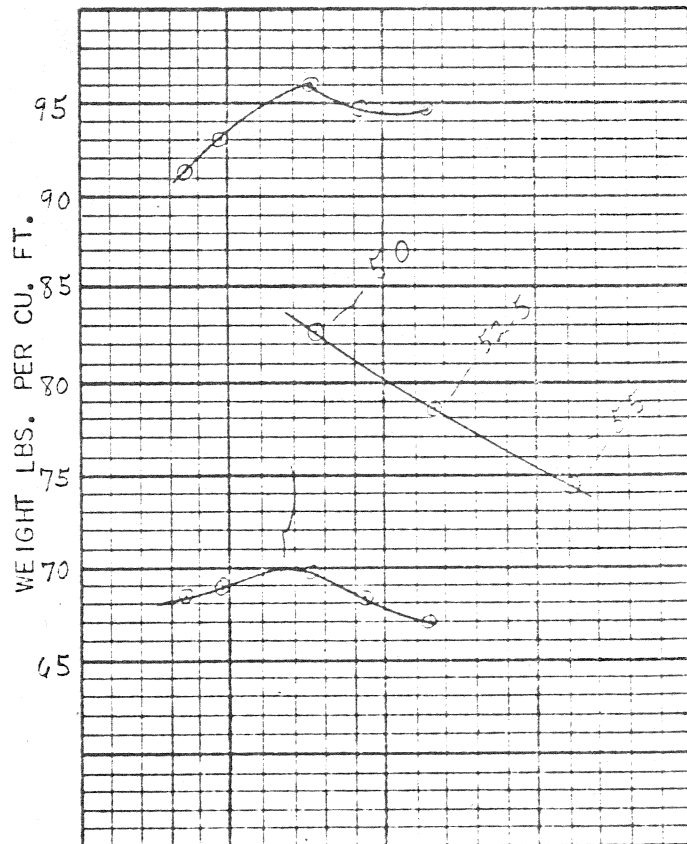
CMP Data

pH- Resistivity ohm. Cm.
 Est. Time To Perforation (16 ga.)
 Add 12 years for Bituminous Coating

Remarks



MOISTURE-DENSITY CURVE

AASHTO DESIGNATION T-99 METHOD AMax. Dry Wt. 70.0 #/Cu. Ft. Opt. Moist. 36.7 %Corrected Max. Dry Wt. = lb/Cu. Ft.(Correction at % passing the 3/4")

Δ Wt./Cu. Ft. From "R" Value 45
30 35 40
 MOISTURE IN PER CENT

This report covers only material as represented by this sample and does not necessarily cover all soil from this layer or source.

Date Mailed AUG 18 1972C. B. HUMPHREY P. E.

GRAPH I

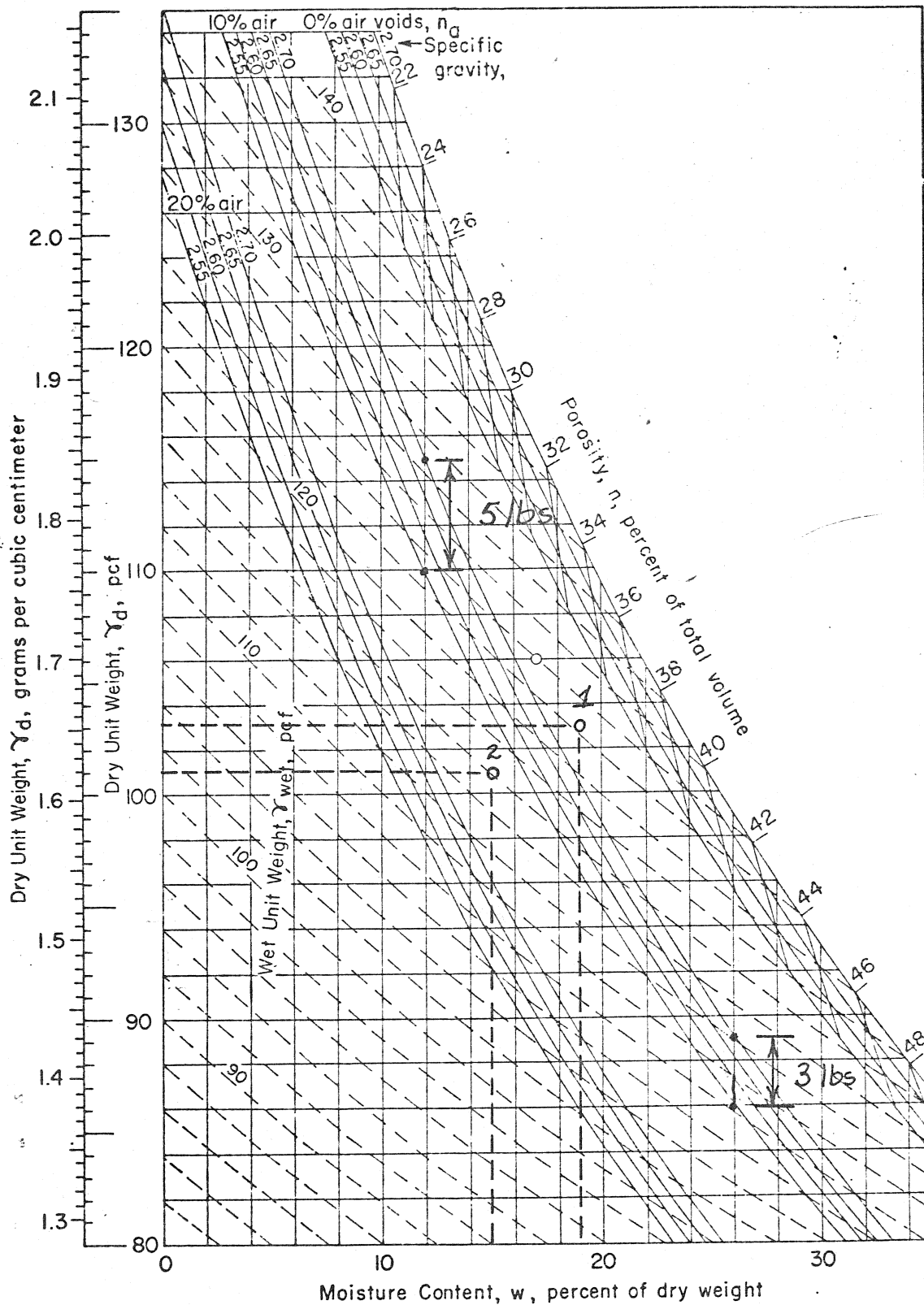


Chart of solids-water-voids relations of soil masses (source, Bureau of Public Roads).

GRAPH 21

Specific Gravity - 2.75

Sandpoint

Dry Density (pcf)

Test No.

% COMPACTION
by PROCTOR METHOD

1
2
3
4

99
105
100
107

0% Air Voids
5% Air Voids
10% Air Voids
12.5% Air Voids

Percent Moisture

110

Specific Gravity 2.65

105

Idaho - Oregon Line

100

DRY DENSITY (pcf)

95

90

TEST No.

% COMPACTION
by PROCTOR METHOD1
2
3
4
5
6
7100
103
103
106
104
92
99

85

80

75

70

65

60

0% Air Voids

5% Air Voids

10% Air Voids

12.5% Air Voids

PERCENT MOISTURE

24

GRAPH IV

Specific Gravity - 2.65

Hammett

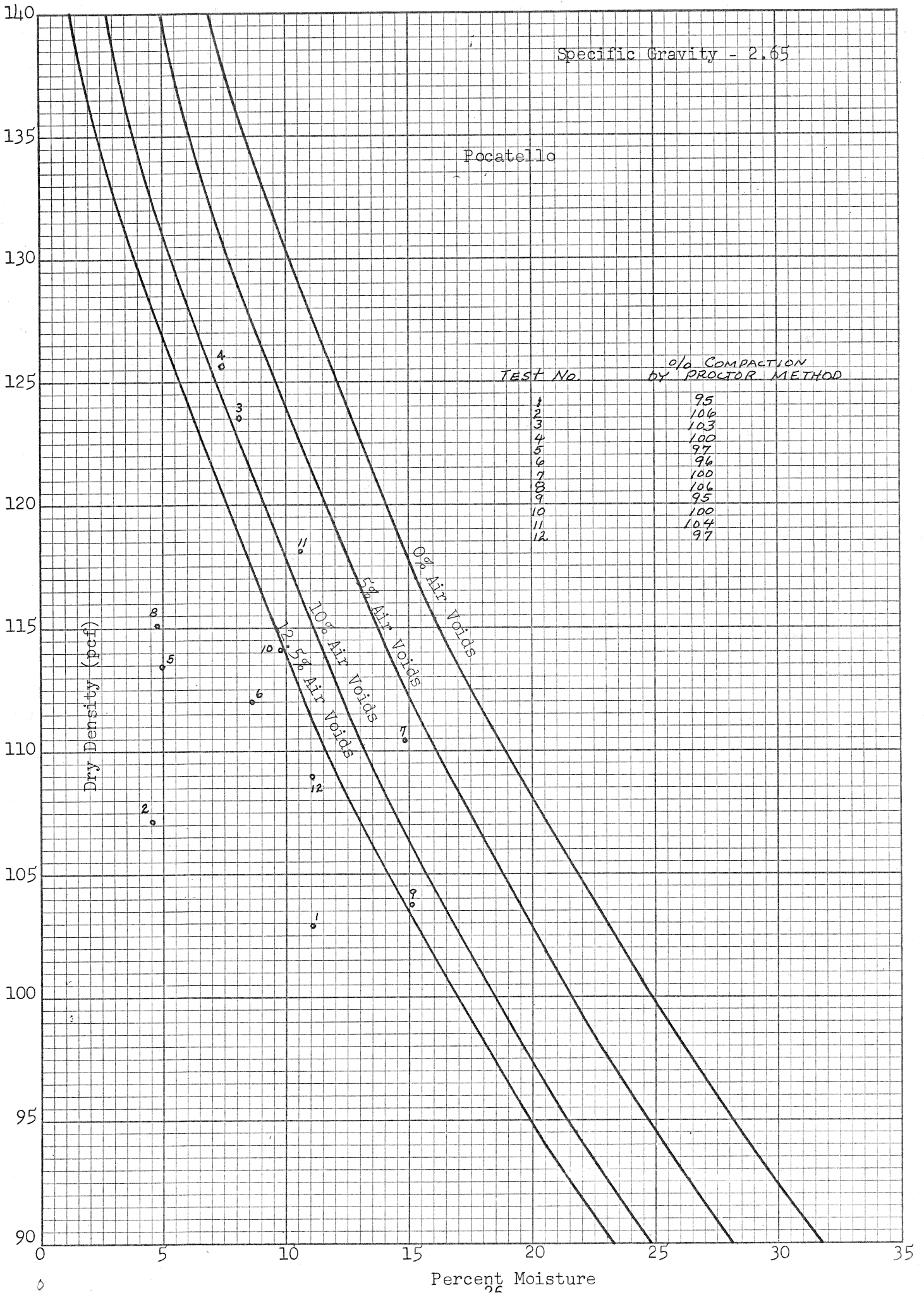
Dry Density (pcf)

Test No.	% Compaction by PROCTOR METHOD
1	97
2	103
3	—
4	97
5	99
6	101
7	102
8	100
9	99
10	100
11	97
12	99

KE 10 X 10 TO THE INCH 46 0700
7 X 10 INCHES
MADE IN U.S.A.
KEUFFEL & ESSER CO.

0% Air Voids
5% Air Voids
10% Air Voids
12.5% Air Voids

Percent Moisture



GRAPH VI

